CLAIMS

What is claimed is:

1. A method for providing predictive maintenance of a device, comprising the steps of:

modeling as a time series x_n of a discretely sampled signal representative of occurrences of a defined event in the operation of said device, said time series x_n being modeled as two-state first order Markov processes with associated transition probabilities p(i|j), wherein state 1 applies when the number of said occurrences exceeds a certain threshold T, and state 0 applies when the number of said occurrences falls below said certain threshold T , being represented as:

$$S_n = \begin{cases} 0 & if \quad x_n \leq T \\ 1 & if \quad x_n > T \end{cases}$$

wherein said transition probability p(i|j) is the switching probability from state j to state i, that is, the probability that $S_n = i$ given that $S_{n-1} = j$, being a total of 4 transition probabilities;

computing said four transition probabilities the last N states S_n, where N is a predetermined number;

conducting a supervised training session utilizing a set of J devices, which have failed due to known causes and considering the two independent probabilities p(1|1) and p(1|0), said training session comprising:

computing the two-dimensional feature vectors $f_i = \{p(1|1), p(1|0)\}_i$ for the initial M windows of N scans,

computing the two-dimensional feature vectors $f_f = \{p(1|1), p(1|0)_f$ for the final N number of scans,

plotting a scatter-diagram of all 2D feature vectors $(f_i)_n$ and $(f_f)_n$, (n = 1…J), and

deriving a pattern classifier by estimating the optimal linear discriminant which separates the two foregoing sets of vectors; and

applying said classifier to monitor the persistence of occurrences of said defined event in the operation of said device.

2. A method for providing predictive maintenance of a device as recited in claim 1, including the steps of:

updating said transition probabilities at each scan are updated; and

constructing the feature vector $f = \{p(1|1), p(1|0)\}$ constructed.

3. A method for providing predictive maintenance of a device as recited in claim 2, including the step of:

providing a warning of imminent failure of said device if f falls into a region of said classifier corresponding indicating such failure prediction.

4. A method for providing predictive maintenance of an X-ray tube, comprising the steps of:

modeling as a time series x_n of a discretely sampled signal representative of occurrences of arcing in the operation of said tube, said time series x_n being modeled as two-state first order Markov processes with associated transition probabilities $p(i|j)$, wherein state 1 applies when the number of said occurrences exceeds a certain threshold T, and state 0 applies when the number of said occurrences falls below said certain threshold T , being represented as:

$$S_n = \begin{cases} 0 & if \quad x_n \le T \\ 1 & if \quad x_n > T \end{cases}$$

wherein said transition probability $p(i|j)$ is the switching probability from state j to state i, that is, the probability that $S_n = i$ given that $S_{n-1} = j$, being a total of 4 transition probabilities;

computing said four transition probabilities the last N states S_n, where N is a predetermined number;

conducting a supervised training session utilizing a set of J X-ray tubes, which have failed due to known causes and considering the two independent probabilities $p(1|1)$ and $p(1|0)$, said training session comprising:

computing the two-dimensional feature vectors $f_i = \{p(1|1), p(1|0)\}_i$ for the initial M windows of N scans,

computing the two-dimensional feature vectors $f_f = \{p(1|1), p(1|0)_f$ for the final N number of scans,

plotting a scatter-diagram of all 2D feature vectors $(f_i)_n$ and $(f_f)_n$, ($n = 1 \ldots J$), and

deriving a pattern classifier by estimating the optimal linear discriminant which separates the two foregoing sets of vectors; and

applying said classifier to monitor the persistence of occurrences of said arcing in the operation of said X-ray tube.

5. A method for providing predictive maintenance of an X-ray tube as recited in claim 4, including the steps of:

updating said transition probabilities at each scan are updated; and

constructing the feature vector $f = \{p(1|1), p(1|0)\}$ constructed.

6. A method for providing predictive maintenance of an X-ray tube as recited in claim A5, including the step of:

providing a warning of imminent failure of said X-ray tube if f falls into a region of said classifier corresponding indicating such failure prediction.

7. A method for providing predictive maintenance of a device comprises the steps of modeling as a time series of a discretely sampled signal representative of occurrences of a defined event in the operation of said device, said time series being modeled as two-state first order Markov processes with associated transition probabilities, wherein one state applies when the number of said occurrences exceeds a certain threshold, and the other state applies when the number of said occurrences falls below said certain threshold; computing said four transition probabilities the last N states S_n, where N is a predetermined number, conducting a supervised training session utilizing a set of J devices, which have failed due to known causes and considering the two independent probabilities and, said training session comprising computing the two-dimensional feature vectors for the initial M windows of N scans, computing the two-dimensional feature vectors for the final N number of scans, plotting a scatter-diagram of all 2D feature vectors, and deriving a pattern classifier by estimating the optimal linear discriminant which separates the two foregoing sets of vectors; and applying said classifier to monitor the persistence of occurrences of said defined event in the operation of said device.

8. Apparatus for providing predictive maintenance of a device, comprising:

means for modeling as a time series x_n of a discretely sampled signal representative of occurrences of a defined event in the operation of said device, said time series x_n being modeled as two-state first order Markov processes with associated transition probabilities $p(i|j)$, wherein state 1 applies when the number of said occurrences exceeds a certain threshold T, and state 0 applies when the number of said occurrences falls below said certain threshold T , being represented as:

$$S_n = \begin{cases} 0 & if \quad x_n \le T \\ 1 & if \quad x_n > T \end{cases}$$

wherein said transition probability p(i|j) is the switching probability from state j to state i, that is, the probability that $S_n = i$ given that $S_{n-1} = j$, being a total of 4 transition probabilities;

means for computing said four transition probabilities the last N states S_n, where N is a predetermined number;

means for conducting a supervised training session utilizing a set of J devices, which have failed due to known causes and considering the two independent probabilities p(1|1) and p(1|0), said means for conducting a supervised training session comprising means for:

computing the two-dimensional feature vectors $f_i = \{p(1|1), p(1|0)\}_i$ for the initial M windows of N scans,

computing the two-dimensional feature vectors $f_f = \{p(1|1), p(1|0)_f$ for the final N number of scans,

plotting a scatter-diagram of all 2D feature vectors $(f_i)_n$ and $(f_f)_n$, (n = 1…J), and

deriving a pattern classifier by estimating the optimal linear discriminant which separates the two foregoing sets of vectors; and

means for applying said classifier to monitor the persistence of occurrences of said defined event in the operation of said device.